



# Weather, Energy, and Insurance Derivatives

## Chapter 25

# Pricing Issues (page 581)

- To a good approximation many underlying variables in insurance, weather, and energy derivatives contracts can be assumed to have zero systematic risk.
- This means that we can calculate expected payoff in the real world and discount at the risk-free rate

# Weather Derivatives: Definitions

(page 582)

- Heating degree days (HDD): For each day this is  $\max(0, 65 - A)$  where  $A$  is the average of the highest and lowest temperature in  $^{\circ}\text{F}$ .
- Cooling Degree Days (CDD): For each day this is  $\max(0, A - 65)$
- Contracts specify the weather station to be used

# Weather Derivatives: Products

- A typical product is a forward contract or an option on the cumulative CDD or HDD during a month
- Weather derivatives are often used by energy companies to hedge the volume of energy required for heating or cooling during a particular month
- How would you value an option on August CDD at a particular weather station?

# Energy Derivatives (page 583-586)

Main energy sources:

- Oil
- Gas
- Electricity

# Oil Derivatives (page 583-84)

- Virtually all derivatives available on stocks and stock indices are also available in the OTC market with oil as the underlying asset
- Futures and futures options traded on the New York Mercantile Exchange (NYMEX) and the International Petroleum Exchange (IPE) are also popular

# Natural Gas Derivatives

(page 584)

- A typical OTC contract is for the delivery of a specified amount of natural gas at a roughly uniform rate to specified location during a month.
- NYMEX and IPE trade contracts that require delivery of 10,000 million British thermal units of natural gas to a specified location



# Electricity Derivatives (page 585)

- Electricity is an unusual commodity in that it cannot be stored
- The U.S is divided into about 140 control areas and a market for electricity is created by trading between control areas.



# Electricity Derivatives

continued

- A typical contract allows one side to receive a specified number of megawatt hours for a specified price at a specified location during a particular month
- Types of contracts:  
5x8, 5x16, 7x24, daily or monthly exercise,  
swing options

# How an Energy Producer Hedges Risks

- Estimate a relationship of the form

$$Y = a + bP + cT + \varepsilon$$

where  $Y$  is the monthly profit,  $P$  is the average energy prices,  $T$  is temperature, and  $\varepsilon$  is an error term

- Take a position of  $-b$  in energy forwards and  $-c$  in weather forwards.

# Modeling Energy Prices

(equation 25.1, page 585)

$$d\ln S = [\theta(t) - a\ln S]dt + \sigma dz$$

- For oil  $a$  is about 0.5 and  $\sigma$  is about 20%; for natural gas these parameters are about 1.0 and 40%; for electricity they are about 15 and 150%.

# Insurance Derivatives (page 586)

- CAT bonds are an alternative to traditional reinsurance
- This is a bond issued by a subsidiary of an insurance company that pays a higher-than-normal interest rate.
- If claims of a certain type are above a certain level the interest and possibly the principal on the bond are used to meet claims